CHEMICAL COMPOSITION OF SOME IMPORTANT PLANTS OF SOUTHEASTERN UTAH SUMMER RANGES RELATED TO MULE DEER REPRODUCTION[1]

Jordan C. Pederson[2] and K. T. Harper[3]

ABSTRACT.— Chemical composition of some major forage plants of mountain summer ranges of southeastern Utah is reported. Grasses are shown to contain significantly less nitrogen, phosphorus, potassium, calcium, and magnesium than either forbs or shrubs. Forbs and shrubs are demonstrated to differ significantly only in potassium content; forbs tested contained more potassium than shrubs. The chemical composition of the forage plants is discussed in relation to mule deer reproductive rates. It is concluded that protein and mineral content of the forage of the two ranges considered (the LaSal and Henry mountains) is less likely to affect reproductive rates than is the relative digestibility of grasses, forbs, and shrubs.

The quality of summer forage has been demonstrated to have an effect on body condition, general health, and reproductive capacity of deer (Longhurst et al. 1952, Swank 1956, 1958, Julander et al. 1961, Verme 1962, 1963, Yoakum 1965, Nordan et al. 1968, Snider and Asplund 1974). If the comparative performance of deer on different ranges is to be understood, the nutritional composition of forages consumed on both summer and winter ranges must be known. It is the objective of this paper to provide information on the chemical composition of some important forage plants of the LaSal and Henry mountains of southeastern Utah. Previous work has shown that mule deer (*Odocoileus hemionus*) herds on those mountain ranges differ markedly in respect to reproductive rate (Pederson and Harper 1978). Pederson and Harper (1978) suggested that differences in quality of forage on summer ranges of the two mountain ranges might be responsible for the observed difference in fawn production.

Dietary requirements for whitetailed deer (*Odocoileus virginianus*) have been reported by French et al. (1956), McEwen et al. (1957), Murphy and Coates (1966), Verme (1963, 1965, 1967, 1969), Ullrey et al. (1967, 1971), and Thompson et al. (1973). Although there is little habitat overlap between whitetails and mule deer, it seems likely that nutritional data compiled for whitetails will have some relevance for mule deer nutrition and management. Studies on mule deer food habits and nutrition have been made by Hagen (1939), Bissell et al. (1955), Swank (1956), Urness et al. (1971), McCullock and Urness (1973), Robinette et al. (1973), Urness et al. (1975), and Pack (1976).

Recent investigations have demonstrated that Rocky Mountain mule deer herds resident on the LaSal Mountains produce about 40 percent more fawns per 100 does than do Henry Mountain herds (Pederson and Harper 1978). In an attempt to identify factors responsible for observed reproductive differences, range condition, diseases, and parasites, as well as late winter body conditions of the deer, were evaluated over an eight-year period on the two mountains. Results demonstrated that deer averaged larger per sex and age class on the LaSals than on the Henry Mountains, but neither diseases nor parasites differed significantly between herds. Likewise, deer taken from the two herds could not be shown to differ significantly in respect to body condition in late winter. Winter ranges used by the two herds were similar in respect to both composition and production. In contrast, annual summer forage produc-

[1]Support provided by the Utah Division of Wildlife Resources and the Utah Division of Water Resources.
[2]Utah Division of Wildlife Resources, Springville, Utah 84663.
[3]Department of Botany and Range Science, Brigham Young University, Provo, Utah 84602.

tion on the LaSals averaged almost 65 percent greater than on the Henries (Pederson and Harper 1978). Composition of the forage crop on summer ranges also differed sharply between mountains, with LaSal ranges being dominated by good-quality forbs while Henry Mountain summer ranges were heavily dominated by shrubs and grasses (Pederson and Harper 1978).

In this report, the hypothesis that forage conditions on the summer range are responsible for the greater productivity of the LaSal Mountain deer herd will be investigated. Emphasis is concentrated on nutritional characteristics of major forage species of summer ranges utilized by the two herds.

We greatly acknowledge the help and support given by the following Utah Wildlife Resources personnel: H. D. Stapley, N. V. Hancock, K. L. Nelson, A. Fleck, L. Hall, and N. K. Larsen. Thanks is extended to A. C. Rencher for his help with the statistical analysis of our data and to G. Cronin for her critical review of this manuscript.

Study Areas

The study areas are in southeastern Utah. The LaSal Mountains are east of Moab in Grand and San Juan counties. The Henry Mountains lie southwest of Hanksville in Wayne and Garfield counties. The two areas are about 117 km apart. Both are laccolithic mountains of similar geologic age (Butler 1920, Hunt et al. 1953). Precipitation averages somewhat higher (about 10 percent) on the LaSals than the Henries for comparable vegetation zones (Pederson 1970).

The LaSal herd unit encompasses approximately 221,374 ha. The highest point on the LaSals is Mount Peale at 3,876 m elevation. The Henry Mountain area includes approximately 72,886 ha; the highest point on the range is Mount Ellen at 3,500 m.

Methods and Procedures

During late July 1976, a representative range site in the aspen zone of each mountain site was visited. The study site on the LaSals was at Warner Lake; the Henry Mountain site was at Nasty Flats. At each site, an area about one hectare in size was selected in aspen forest. A composite sample of the surface 1.5 dm of soil and the five most common grass, forb, and shrub forage species were collected for subsequent analysis. All aboveground parts of grasses and forbs and current growth (leaves and twigs) of shrub species were taken. Only grasses and forbs in flowering condition were collected; most shrub species were not in flower. Individual plants of each species were collected until a composite sample of over 75 g fresh weight was acquired. Samples were lightly packed in paper bags and oven dried at 80 C within 48 hours of harvest.

Soil samples were air dried, passed through a 2 mm sieve, and delivered to a commercial, analytical laboratory. Soil pH was determined on a 1:1 soil-to-water mixture with a glass electrode meter. Texture was determined using the hydrometer method, and exchangeable cations were extracted with neutral ammonium acetate and determined by atomic absorption procedures. Nitrogen was measured using micro-Kjeldahl apparatus. Soil organic matter was determined by loss-on-ignition.

Dried plant samples were ground through a 40-mesh sieve in a standard mill. Samples were stored in glass containers until the analyses were completed. Estimates of crude protein were based on total nitrogen as determined by micro-Kjeldahl procedures. All other elements were determined from ash, using standard atomic absorption and colorimetric techniques (American Society of Agronomy 1965).

Differences in chemical composition between species belonging to different life form groups (i.e., grasses, forbs, and shrubs) on the same mountain range and between life forms on different mountain ranges were determined using analysis of variance and Duncan multiple range test. Statistical procedures follow Snedecor and Cochran (1967).

Results

Soils of the two study sites are both of loamy texture (Table 1). Soils at the LaSal study area were slightly more acidic than those at the Henry site. Soil organic matter and nitrogen content were somewhat higher at the LaSal Mountain study area; both variables probably reflect a somewhat better moisture balance at the LaSal site. Soils from the Henry Mountain site have considerably higher phosphorus content and generally higher exchangeable cation levels than the LaSal soils (Table 1).

Chemical composition of the current year, aboveground growth of major species, and current-year twig growth of important browse species of the summer ranges of the LaSal and Henry mountains are reported in Table 2. Average values for grasses differ significantly between mountain ranges. Species from the LaSals contain more nitrogen, potassium, calcium, and magnesium. Phosphorous content of grasses did not differ significantly between mountain ranges. Shrubs of the two mountain ranges differed significantly for nitrogen only, with LaSal shrubs averaging 40 percent more nitrogen than the Henries. Elemental content of plants was strongly correlated with soil content of the same element for nitrogen and phosphorous only. Other elements showed little correlation between amounts in plants and associated soils.

The elemental content of grasses (all species polled) was significantly lower than for either forbs or shrubs for all elements tested. Few significant differences in chemical composition could be demonstrated between forbs and shrubs. Only the potassium content of forbs could be shown to differ significantly from that of shrubs—potassium averaged 138 percent higher in forbs (Table 2).

The average contribution of grasses, forbs, and shrubs to the forage crop of summer ranges of the LaSals and Henries is shown in Table 3. Furthermore, several analyses of the relative preference of mule deer for grasses, forbs, and shrubs during the summer season have been reported (Table 4). Because estimates of chemical (Table 2) and botanical (Table 3) composition of the summer range forage crop of the LaSal and Henry mountains are available, it is possible to combine those data with feeding preference information for mule deer (Table 4) and obtain estimates of the chemical composition of the summer diet of deer on the two ranges.

Assuming deer select grasses, forbs, and shrubs in the proportions reported by any author in Table 4, regardless of the abundance in the vegetation of plants in each life form category, the composition of the diet can be estimated for any element in either of the study areas. For example, to estimate the amount of phosphorus in diets of LaSal mule deer, assuming a feeding preference such as that reported by Smith (1952) in Table 4, sum the products of (1) average percent phosphorus in LaSal grasses times the proportion of grasses in mule deer diets reported by Smith, (2) average percent phorphorus in LaSal forbs times the proportion of forbs in the diet, and (3) the average percent phosphorus in LaSal shrubs times the proportion of shrubs in the diet. For this example, we estimate that mule deer diets on the LaSals should contain .18 percent phosphorus.

The chemical composition of four alternative diets has been estimated in Table 5. Three diets are based on feeding preferences reported by Smith (1952), Morris and Schwartz (1957), and Trout and Thiessen (1968). The fourth diet is based on the assumption that the deer select grasses, forbs,

TABLE 1. Chemical and physical characteristics of soils on the LaSal and Henry mountains study areas.

					ANALYSIS					
Mountain range	pH	Sand %	Silt %	Clay %	Organic matter %	Nitrogen %	Phosphorus ppm	Potassium ppm	Calcium ppm	Magnesium ppm
LaSal Mountains Warner Lake	6.3	48	46	6	8.11	0.47	14.0	417.6	2090.4	105.6
Henry Mountains Nasty Flats	6.7	50	38	12	6.04	0.35	42.4	420.0	2822.4	166.4

and shrubs in exact proportion to their abundance in the vegetation. The results show chemical composition of diets differs relatively little regardless of the assumption used (Table 5). Furthermore, estimated chemical composition of diets does not differ radically between mountain ranges. Even the lowest estimates for each dietary constituent studied appear to be within safe limits for good animal health (Dasmann 1971, Morrison 1961). The calcium/phosphorous ratio also seems to be within normal limits (Table 5).

Discussion

The results indicate that differences in plant chemistry between the two mountain ranges for the elements considered in this paper are probably not responsible for the observed reproductive differences between mule deer herds resident on the two mountain ranges. However, it cannot be concluded that summer range forage is not responsible for the observed differences in deer reproduction. The digestible energy content is unknown for the species considered in this re-

TABLE 2. Chemical composition of current year, aboveground growth of some major forage species of the summer ranges of the LaSal (L) and Henry (H) mountains of southeastern Utah. Specimens for analysis were collected on 26 and 27 July 1976. Composition values have been averaged by plant life form group and mountain range.

SPECIES	NITROGEN		PHOSPHORUS		POTASSIUM		CALCIUM		MAGNESIUM	
	L	H	L	H	L	H	L	H	L	H
					Percent					
GRASSES										
Agropyron trachycaulum	1.51	0.91	0.12	0.12	1.88	0.89	0.26	0.27	0.07	0.08
Bromus carinatus	1.79	–	0.17	–	2.60	–	0.44	–	0.12	–
Carex geyeri	1.16	–	0.12	–	1.81	–	0.34	–	0.13	–
Elymus glaucus	1.82	–	0.13	–	2.61	–	0.35	–	0.09	–
Festuca ovina	–	1.30	–	0.11	–	1.06	–	0.26	–	0.07
Festuca thurberi	–	0.99	–	0.10	–	1.75	–	0.22	–	0.07
Sitanion hystrix	–	1.15	–	0.11	–	1.64	–	0.17	–	0.06
Stipa columbiana	1.19	1.11	0.12	0.13	1.82	1.55	0.33	0.33	0.08	0.08
Average by mountain range	1.50[a]	1.09[b]	0.13[a]	0.11[a]	2.14[a]	1.38[b]	0.35[a]	0.25[b]	0.10[a]	0.07[b]
Pooled average	1.305[c]		0.123[c]		1.762[c]		0.300[c]		0.085[c]	
FORBS										
Chenopodium fremontii	–	3.14	–	0.25	–	7.90	–	1.18	–	0.76
Erigeron speciosus	1.77	–	0.18	–	3.35	–	1.01	–	0.15	–
Helianthella quinquenervis	1.62	–	0.23	–	4.53	–	1.65	–	0.28	–
Hymenoxys richardsonii	–	1.54	–	0.20	–	3.05	–	1.29	–	0.26
Ligusticum porteri	1.55	–	0.19	–	4.74	–	1.34	–	0.25	–
Lupinus parviflorus	2.49	–	0.15	–	2.29	–	1.44	–	0.34	–
Oxytropis sericeus	–	1.92	–	0.18	–	1.91	–	0.98	–	0.16
Penstemon watsonii	–	1.12	–	0.15	–	1.88	–	1.16	–	0.26
Senecio ambrosioides	–	1.62	–	0.19	–	3.24	–	1.01	–	0.23
Thalictrum fendleri	1.44	–	0.19	–	2.19	–	0.87	–	0.12	–
Average by mountain range	1.77[a]	1.87[a]	0.18[a]	0.19[a]	3.42[a]	3.59[a]	1.26[a]	1.12[a]	0.23[a]	0.33[a]
Pooled average	1.820[d]		0.192[d]		3.509[d]		1.195[d]		0.281[d]	
SHRUBS										
Artemisia tridentata vaseyana	–	1.92	–	0.20	–	2.09	–	0.49	–	0.15
Populus tremuloides	1.96	1.51	0.13	0.15	1.06	1.38	1.20	0.60	0.20	0.17
Prunus virginiana	2.57	–	0.30	–	1.55	–	1.71	–	0.33	–
Ribes cereum	–	1.19	–	0.20	–	1.02	–	0.94	–	0.26
Rosa woodsii	1.84	1.86	0.19	0.22	1.09	1.27	1.03	1.59	0.33	0.38
Salix lasiandra	2.59	–	0.16	–	1.29	–	1.33	–	0.26	–
Symphoricarpos oreophilus	1.86	1.23	0.17	0.18	1.90	2.08	1.10	0.63	0.29	0.23
Average by mountain range	2.16[a]	1.54[b]	0.19[a]	0.19[a]	1.38[a]	1.57[a]	1.27[a]	0.85[a]	0.28[a]	0.24[a]
Pooled average	1.853[d]		0.191[d]		1.474[d]		1.064[d]		0.262[d]	

Superscripts a and b are used to indicate significance of difference ($P<0.05$ or better) of averages for a specific plant life form and nutrient element between mountain ranges. Pooled averages for a specific lifeform and element on both mountain ranges were tested for statistically significant differences from pooled averages of the same element in other life form groups on the same mountain ranges. Pooled averages that differ significantly ($P<0.05$ or better) have different superscripts (i.e., c and d); averages that do not differ significantly are followed by the same letter.

port, but there is evidence that deer are unable to digest shrub tissue well enough to supply adequate energy for even maintenance requirements (Nordan et al. 1968, Walmo et al. 1977). Much data exist to show that forbs are generally more digestible than is shrub tissue (Nordan et al. 1968, Torgerson and Pfander 1971, Short 1971, Urness 1973, Snider and Asplund 1974, Walmo et al. 1977). The data also suggest that grasses are more digestible than shrubs. If deer diets on the two mountains do diverge widely in respect to the mix of forbs, grasses, and shrubs, summer range forage may exert a significant influence on deer reproduction through the energy component of the diets.

TABLE 3. Average relative contribution by weight of grasses, forbs, and shrubs to the forage crop of summer ranges on the LaSal and Henry mountains. Data from Pederson and Harper (1978, Table 4).

Plant group	Mountain Range	
	LaSals	Henries
	Percent	
Grasses	21	13
Forbs	52	12
Shrubs	27	75

As noted in Table 3, the LaSal and Henry Mountains do differ greatly in composition of the forage crop of their summer ranges. Pederson (1970) has shown that the LaSals not only produce more forb biomass than the Henries, but that they also have about twice as many forb species for deer to select from as do the Henries (i.e., 90 forbs species sampled on the LaSals compared to 45 sampled on the Henries). Given the great difference between summer ranges on the two mountains, it seems likely that Henry Mountain deer consume more shrub and less forb tissue in summer diets than do animals on the LaSals.

Does that feed heavily on shrubs may have difficulty meeting the energy demands of daily maintenance, lactation, and weight gains required to compensate for weight lost on winter ranges. Cook's (1972) data suggest that stress will be most severe in late summer. Does that do become stressed by late season energy deficits could respond to the stress in at least three ways: (1) continue to lactate heavily at the expense of personal body condition, (2) lactate poorly and reduce body condition of the fawn and self, or (3) abandon the fawn and devote more energy to personal well-being. Option (1) would keep

TABLE 4. Relative dietary intake (percent by volume) of plants of different life form groups by mule deer on summer ranges.

Location	Percent intake of Grasses	Forbs	Shrubs	Source of data
Southwestern Idaho	10	9	81	Trout and Thiessen (1968)
Western Montana	1	70	29	Morris and Schwartz (1957)
Northern Utah	5	68	27	Smith (1952)

TABLE 5. Comparative chemical composition of four possible mule deer diets on the LaSal and Henry mountains of southeastern Utah.

	LaSal Mountains		Henry Mountains		
	Average % in four diets	Range	Average % in four diets	Range	% differences based on averages
Protein	11.9	11.6 -12.9	10.2	9.5 -11.0	17 (LaSals higher)
Phosphorus	.18	.17- .18	.18	.18- .19	5 (Henries higher)
Potassium	2.5	1.6 - 2.8	2.4	1.7 - 3.0	5 (LaSals higher)
Calcium	1.2	1.1 - 1.3	.9	.8 - 1.0	29 (LaSals higher)
Magnesium	.24	.22- .26	.26	.23- .30	9 (Henries higher)
Calcium/phosphorus	6.7	6.5 - 7.2	5.0	4.4 - 5.3	34 (LaSals higher)

fawn survival high, but lower doe survival; option (2) would reduce survival of both does and fawns; and option (3) would drastically reduce fawn survival, but contribute to better doe survival. Low fawn production on the Henries may indicate that does there are exercising option (2) or (3) or both.

The differential fawn production on the LaSal and Henry mountains could be better understood if the composition of summer diet in the two herds was known. With such data, digestibility studies of the major plant components in the diet could be made. Fortunately, recent developments in fecal pellet analysis make it possible to obtain direct information about dietary composition at reasonable costs (Vavra et al. 1978). Plant digestibility can be economically estimated with *in vitro* methods (Urness 1973, Snider and Asplund 1974).

Literature Cited

American Society of Agronomy. 1965. Methods of soil analysis, Part 2. Chemical and Microbiological Properties. Am. Soc. of Agron., Inc., Madison, Wisconsin.

Bissell, H. D., B. Harris, H. Strong, and F. James. 1955. The digestibility of certain natural and artificial foods eaten by deer in California. Calif. Fish and Game 41:57–78.

Butler, B. S., G. F. Laughlin, V. C. Heikes, and others (sic). 1920. The ore deposits of Utah. Professional Paper 111. U.S. Geological Survey, Government Printing Office, Washington, D.C.

Cook, C. W. 1972. Comparative nutritive value of forbs, grasses and shrubs. p. 303–310. *In*: C. M. McKell et al. (eds.), Wildland shrubs—their biology and utilization. U.S. Dept. Agr. Forest Serv., General Tech. Rep. INT-1.

Dasmann, W. 1971. If deer are to survive. Stackpole Books, Harrisburg, Pa. 128 pp.

French, C. E., L. C. McEwen, N. D. Magruder, R. H. Ingram, and R. W. Swift. 1956. Nutrient requirements for growth and antler development in the white-tailed deer. J. Wildlife Manage. 20:221–232.

Hagen, H. L. 1939. Nutritive value for deer of some forage plants in the Sierra Nevada. Calif. Fish and Game. 39:163–175.

Hunt, C. B., P. Averitt, and R. L. Miller. 1953. Geology and geography of the Henry Mountains region, Utah. Geol. Surv. Prof. Pap. No. 228. 234 pp.

Julander, O., W. L. Robinette, and D. A. Jones. 1961. Relation of summer range condition to mule deer herd productivity. J. Wildlife Manage. 25:54–60.

Longhurst, W. M., A. S. Leopold, and R. F. Dasmann. 1952. A survey of California deer herds, their ranges and management problems. Calif. Dept. Fish and Game, Game Bull. 6. 136 pp.

McCulloch, C. Y., and P. J. Urness. 1973. Deer nutrition in Arizona chaparral and desert habitats. Special Report No. 3. Research Division, Arizona Game and Fish Dept. 68 pp.

McEwen, L. C., C. E. French, N. D. Magruder, R. W. Swift, and R. H. Ingram. 1957. Nutrient requirements of the white-tailed deer. Trans. N. Amer. Wildlife Conf. 22:119–132.

Morris, M. S., and J. E. Schwartz. 1957. Mule deer and elk food habits of the National Bison Range. J. Wildlife Manage. 21:189–193.

Morrison, F. B. 1961. Feeds and feeding, abridged. Morrison Publishing Co., Claremont, Ontario, Canada. 696 pp.

Murphy, D. A., and J. A. Coates. 1966. Effects of dietary protein on deer. Trans. N. Amer. Wildlife Conf. 31:129–139.

Nordan, H. C., I. Cowan, and A. J. Wood. 1968. Nutritional requirements and growth of black-tailed deer, *Odocoileus hemionus columbianus*, in captivity. pp. 89–96. *In*: M. A. Crawford, ed. Comparative nutrition of wild animals. Symp. Zool. Soc. London. Academic Press, New York.

Pack, C. L. 1976. Productivity of two Utah deer herds as related to nutrition. Unpublished thesis. Utah State Univ. Logan, Utah. 110 pp.

Pederson, J. C. 1970. Productivity of Mule deer on the LaSal and Henry mountains of Utah. Utah State Division Fish and Game Pub. 70-2. 135 pp.

Pederson, J. C., and K. T. Harper. 1978. Factors influencing productivity of two mule deer herds in Utah. J. Range Manage. 31:105–110.

Robinette, W. L., C. H. Baer, R. E. Pillmore, and C. E. Knittle. 1973. Effects of nutritional change on captive mule deer. J. Wildlife Manage. 37:312–326.

Short, H. L. 1971. Forage digestibility and diet of deer on southern upland range. J. Wildlife Manage. 35:698–706.

Smith, J. G. 1952. Food habits of mule deer in Utah. J. Wildlife Manage. 16:148–155.

Snedecor, G. W., and W. G. Cochran. 1967. Statistical methods, 6th ed. Iowa State University Press, Ames. 593 pp.

Snider, C. C., and J. M. Asplund. 1974. In vitro digestibility of deer foods from the Missouri Ozarks. J. Wildlife Manage. 38:20–31.

Swank, W. G. 1956. Protein and phosphorus content of browse plants as an influence on southwestern deer herd levels. Trans. N. Amer. Wildlife Conf. 21:141–158.

_____. 1958. The mule deer in Arizona chaparral. Arizona Fish and Game Dept. Wildlife Bull. No. 3. 109 pp.

Thompson, C. B., J. B. Holter, H. H. Hayes, H. Silver, and W. E. Urban, Jr. 1973. Nutrition of white-tailed deer. I. Energy requirements of fawns. J. Wildlife Manage. 37:301–311.

Torgerson, O., and W. H. Pfander. 1971. Cellulose digestibility and chemical composition of Missouri deer foods. J. Wildlife Manage. 35:121–131.

Trout, L. E., and J. L. Thiessen. 1968. Food habits and condition of mule deer in Owyhee County. Proc. Western Assn. State Game and Fish Comm. 48:188-200.

Ullrey, D. E., W. G. Youatt, H. E. Johnson, L. D. Fay, and B. L. Bradley. 1967. Protein requirements of white-tailed deer fawns. J. Wildlife Manage. 31:679-685.

Ullrey, D. E., M. E. Johnson, W. G. Youatt, L. D. Fay R. L. Schoepke, and W. T. Magee. 1971. A basal diet for deer nutrition research. J. Wildlife Manage. 35:57-62.

Urness, P. J. 1973. Deer nutrition in Arizona chaparral and desert habitats. Part II: Chemical analyses and in vitro digestibility of seasonal deer forages. Arizona Fish and Game Dept., Special Report No. 3:39-52.

Urness, P. J., W. Green, and R. K. Watkins. 1971. Nutrient intake of deer in Arizona chaparral and desert habitats. J. Wildlife Manage. 35:469-475.

Urness, P. J., D. J. Neff, and J. R. Vahle. 1975. Nutrient content of mule deer diets from ponderosa pine range. J. Wildlife Manage. 39:670-673.

Vavra, M., R. W. Rice, and R. M. Hansen. 1978. A comparison of esophageal fistula and fecal material to determine steer diets. J. Range Manage. 31:11-13.

Verme, L. J. 1962. Mortality of white-tailed deer fawns in relation to nutrition. Proc. Nat. Deer Dis. Symp. 1:15-38.

______. 1963. Effects of nutrition on growth of white-tailed deer fawns. Trans. N. Amer. Wildlife Conf. 38:431-442.

______. 1965. Production studies on penned white-tailed deer. J. Wildlife Manage. 29:74-79.

______. 1967. Influence of experimental diets on white-tailed deer reproduction. Trans. N. Amer. Wildlife and Nat. REsources Conf. 32:405-420.

______. 1969. Reproductive patterns of white-tailed deer related to nutritional plane. J. Wildlife Manage. 33:881-887.

Walmo, O. L., L. H. Carpenter, W. L. Regelin, R. B. Gill, and D. L. Baker. 1977. Evaluation of deer habitat on a nutritional basis. J. Range Manage. 30:122-127.

Yoakum, J. 1965. Life and death of deer herds. pp. 11-19. *In*: Univ. California Agr. Ext. Serv. Deer Seminars. Agr. Ext. Serv., Univ. of California, Eureka. 39 pp.